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COAL DRYING PROCESS IN A FLUIDIZED BED UNIT

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Abstract: The article presents the process of preparing coal for grinding at conventional thermal power plants, analyzing its shortcomings and ways to address them. As a result of the analysis, the results of experiments conducted to study the coal drying process in a fluidized bed apparatus were presented, and drying curves and drying rate were constructed. The dependence of the obtained results not only on the grade of the coal but also on its fineness is shown in specific examples. The results are compared with the results obtained using existing methods, and the sequence of experiments is fully described. In addition, there are studies related to the study of changes in the moisture content of coal and air.
Keywords: Boiling layer dryer, humidity, ash content, crusher, coal, Angren B2 brand, drying speed.

Introduction. In coalfired thermal power plants, solid fuel is burned in the form of crushed particles. Figure 1 shows the basic diagram of combustion of solid fuel in powder form [1]. Solid fuel delivered to the power plant by rail is loaded into a bunker using a car dumper. After the bunker, coal is sent to the crushing body using a belt conveyor. In the crushing body, the coal is crushed to a size of 25 mm. After that, the crushed coal, which entered the bunker installed in the boiler room, is crushed and dried in coal mills to 300500 µm, and then sprayed into the boiler furnace through the burners. Primary air heated from 250 to 450 0C using a convective air heater installed in the gas tract is used to dry the fuel. Secondary air is directed directly to the furnace through the burner to carry out the combustion process.

The station also carries out drying and enrichment operations, only in this case magnetic enrichment is used, which cleans coal from metal compounds. Heated air is used for drying.

Problem statement. In this case, reducing the moisture content of coal does not give a complete result. There are also a number of disadvantages in separating it from solids. Namely, the constant content of nonmetallic substances leads to corrosion of the boiler surfaces and other contact surfaces.

Main section. To eliminate these problems and improve the quality of coal, it is advisable to introduce a new method of drying and enrichment with a fluidized bed.

The proposed fluidized bed device is installed after the crusher, which reduces the ash and moisture content. This leads to an increase in the thermal conductivity of the boiler surfaces.

In order to implement this method in practice, a number of studies of the device for drying and separating solid minerals with a fluidized bed were carried out based on theoretical data.

The Angren TPP was taken as the object of study. During the experiments, it was determined how much the heat transfer capacity could be increased by burning dried and enriched coal in a fluidized bed device.

The research device was connected to three air blowers, each with a power of 200 W, the speed of the supplied air and a number of other parameters were determined. The device is completely insulated, and the lid is also made hermetic.

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Initially, to carry out the drying process, coal particles weighing 3040 g (measured on electronic scales) were fed into the fluidized bed device, the size of which was set in 4 groups: 1.253; 35; 57; 710 equivalent diameter sizes. In this case, the initial temperature of the supplied air and flue gas mixture was in the range of 100140 0C. The initial values of the coal and air (flue gas mixture) parameters were determined on the basis of existing norms and standards [2; 3; 4]. Then it was fed into the device, and the drying and enrichment processes were carried out. At the outlet, the moisture content of the dried coal was determined using existing standard methods. The time of change in the initial and final moisture content of the coal and the change in the temperature of the coal were determined experimentally. As a result, it was established how the drying curve changed depending on the size of the coal particles. For this, particles of 310 mm in size were fed into the device 3 times. Since the device consists of three sections, the moisture content was determined as the coal passed through each section, creating a basis for constructing the drying kinetics. To determine how much the ash content of the coal changed, the same was done, determining the amount of ash at the input and output of the section. During the drying and enrichment of coal, a decrease in the initial mass is observed, i.e. the mass decreases. To determine this value and determine the ash content and moisture content of the coal, experiments were conducted using electronic scales. To ensure the reliability and consistency of the results, the experiment was repeated twelve times. As a result of this experimental experiment, it was established that the drying curve, the abstract boiling curve or the pressure acting on the bed depend on the speed of the supplied air and the change in heat transfer capacity during coal drying and its separation from solid minerals.
During the experiment, the first and second critical speeds were determined, and the hydraulic resistance increased with an increase in the air volume, and only between the first and second critical speeds did it not change its value, that is, it was constant. After the ash content and moisture content of the coal had changed according to the experimental results, the increase in the net calorific value was determined using a calorimeter [5,6,7] depending on these parameters.
As a result of the experiments on coal drying and enrichment in the abstract boiling bed apparatus, the following data were obtained (Table 1).

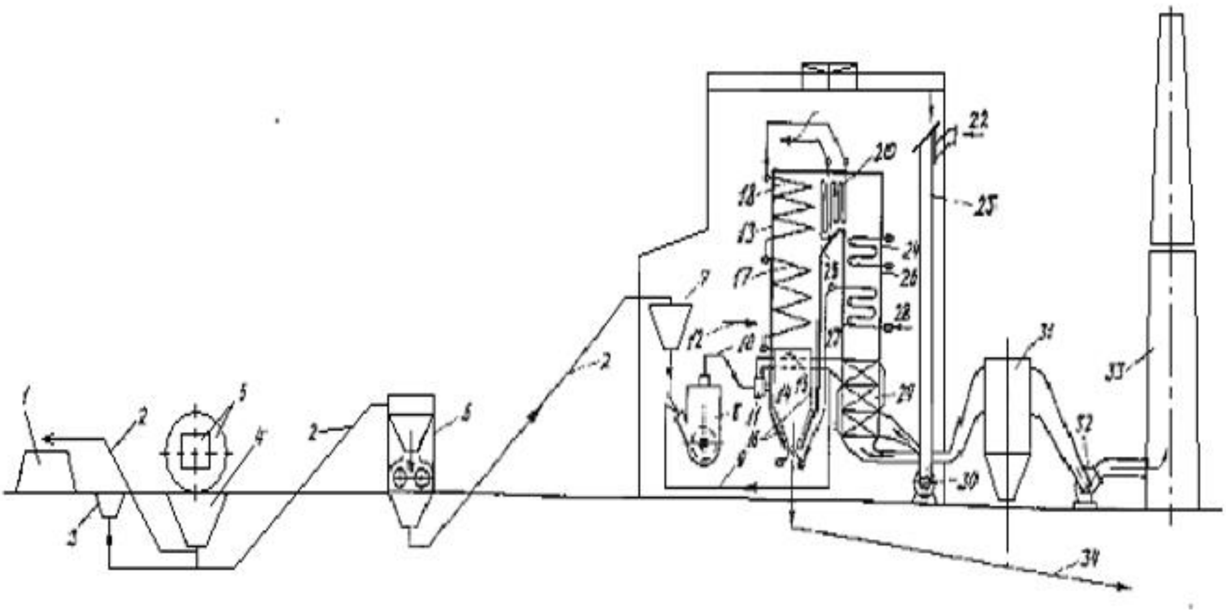

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Figure 1. Flow chart of solid fuel TPP steam boiler house:
1 - fuel bundle; 2 - belt conveyor; 3, 4 - fuel bin; 5 - fuel carrier; 6 - fuel grinding unit; 7 - intermediate bin; 8 - mill; 9 - primary air; 10 - ground fuel; 11- burner; 12 - boiler front; 13 - heatinsulating layer; 14 - combustion chamber; 15 - secondary air; 16 - lower radiation screens; 17, 18 - combustion screens; 19 - superheated steam; 20 - superheater; 21, 22 - atmospheric air; 23 - cold air pipeline; 24 - intermediate steam superheating; 25 - horizontal gas path; 26 - transition zone; 27 - economizer; 28 - feed water; 29 - air heating; 30 - fan; 31 - cultivator; 32 - smoke exhauster; 33 - smoke stack; 34 - device for transporting ash and slag.

Table 1

Changes in key parameters based on experience

№	B №	d,мм	m_1, г	m_2, г	t_1, ^0C	t_2, ^0C	G, $м^3$/с	v, м/с	u_1, %	u_2, %	A_1, %	A_2, %
1	76	(510)	32.	26.33	80	40	160	17	28	12	39,8	20
2	64	(35)	35	24.07	80	40	160	17	28	9	41,9	17,3
3	71	(1,253)	32,24	29.07	80	40	160	17	28	8	39	26,5
4	63	(35)	36,48	27.66	80	40	160	17	28	8.5	40,2	19

The table above clearly shows that the ash content and humidity decrease when the coal pieces are dried and separated from solid minerals. In addition, the amount of coal fed during operation of the device, the air flow rate at the inlet and outlet, the speed and temperature were measured [8; 9; 10]. Based on the values obtained during the experiments, the dependence of humidity on the drying time was obtained. When the humidity changes, the drying time changes accordingly. This can be seen from Table 2. A drying curve was plotted based on the values given in the table. Coal pieces with equivalent diameters from 3 mm to 10 mm were studied, and a separate drying curve was obtained for each [11; 12; 13; 14]. A thermogram of temperature change was also plotted relative to the curve plotted based on the experiments conducted on mediumsized coal pieces (Figure 2).

Table 2

Change in humidity over time

Humidity change (35) (35)	τ, min	Humidity change (35) (35)	τ, min	Humidity change (35) (510)	τ, min	Humidity change (35) (1.253)	τ, min
28	0,5	28	0,5	28	1	28	0,2
25	0,8	24	0,8	26	1,2	26	0,3
22	1	21	1	24	1,5	23	0,5

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19	1,3	18	1,3	23	1,6	20	0,7
16	1,8	15	1,8	20	2,2	17	0,9
13	2,1	12	2,1	19	2,5	14	1,2
11	2,8	10	2,8	17	2,9	11	1,5
9	3,5	8,5	3,5	14	4	8	2

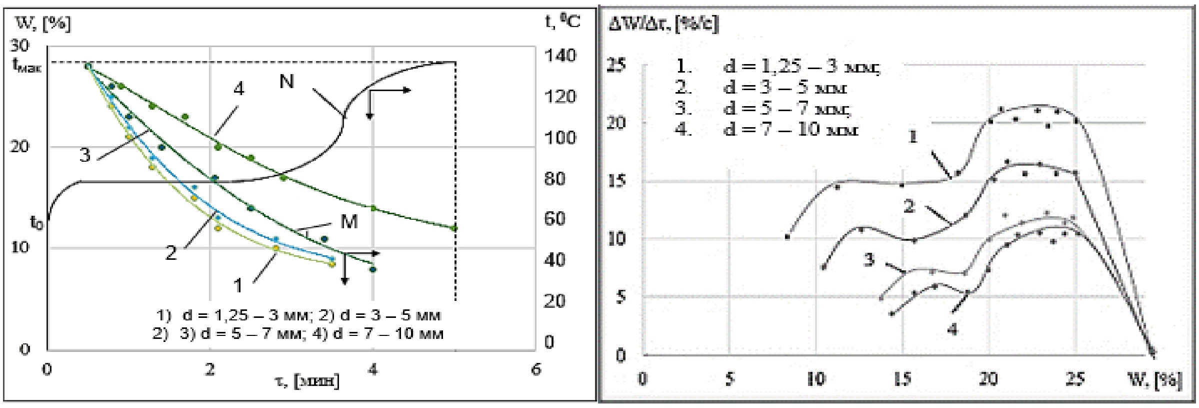
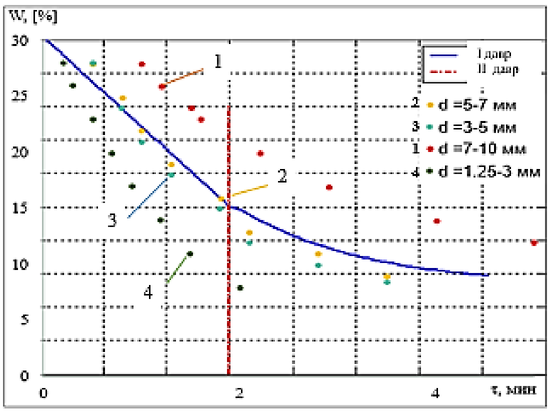
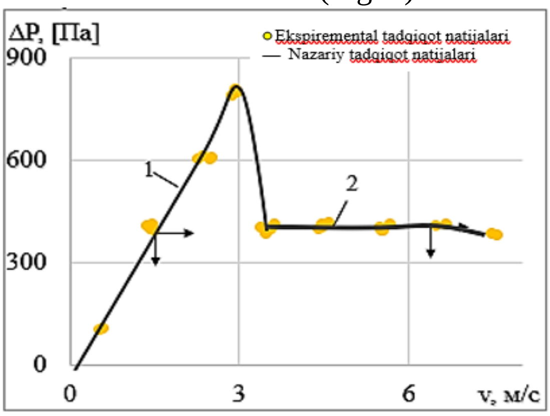


Fig. 2. Drying curve and drying rate curves

To plot the drying rate curve, it was necessary to differentiate the drying curve and these steps were performed [15;16]. By plotting this curve, it is possible to determine how the moisture is related to the coal and the heat spent on reducing the moisture content of the material (Fig. 2). The following graph was obtained by comparing the drying curve plotted as a result of the research with the drying curves obtained using the mathematical model (Fig. 3).





1) $u = 0.3 - 0.075t;$

2) $u = 0.13 - 0.02e^{(-4.0439(t-16))}$

$$P_1 = -186.67 \cdot v^5 + 1933.33 \cdot v^4 \pm 7833.33 \cdot v^3 + 15516.67 \cdot v^2 - 14630 \cdot v + 5300;$$

$$P_2 = -0.0066 \cdot v^4 + 0.3909 \cdot v^3 + -8.29 \cdot v^2 + 54.58 \cdot v + 292.05$$

Fig. 3. Drying curve obtained based on research results and using a mathematical model

Fig. 4. Graphs of the dependence of the hydraulic resistance of the fluidized bed Δ*P* on the air velocity *v* and empirical equations of the process.

To study the enrichment process in the developed apparatus, the fluidization curve was studied. Samples weighing from 40 g to 200 g were loaded into the fluidized bed unit. The hydraulic resistance of the bed was determined using a Ushaped manometer, and the first and second critical velocities were measured using an anemometer. In the constructed graph, the

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compatibility of the study values and the mathematical model was checked in MS Excel, the shift distance between the two graphs was 7.8%. The studies were carried out at the same temperature.

Conclusion. The article presents the results of preliminary experiments conducted to reduce the moisture and ash content of Angren B2 coal using a fluidized bed apparatus. In this case, the drying curve and drying rate curves were mainly plotted, and the coal drying rate in the fluidized bed apparatus was determined. As a result of the determinations, it was established that the proposed method has a higher drying rate and is more effective in reducing humidity than other methods. As a result of the experiments, the maximum drying rate was 5 minutes. The main reason for achieving such a speed is that the surfaces of small coal particles are completely washed by hot air.

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